Abstract. In the standard Cold Dark Matter (CDM) theory of structure formation, virialized minihalos (with \( T_{\text{vir}} \leq 10,000 \text{K} \)) form in abundance at high redshift \((z \gtrsim 6)\), during the cosmic “dark ages.” The hydrogen in these minihalos, the first nonlinear baryonic structures to form in the universe, is mostly neutral and sufficiently hot and dense to emit strongly at the 21-cm line. We calculate the emission from individual minihalos and the radiation background contributed by their combined effect. Minihalos create a “21-cm forest” of emission lines. We predict that the angular fluctuations in this 21-cm background should be detectable with the planned LOFAR and SKA radio arrays, thus providing a direct probe of structure formation during the “dark ages.” Such a detection will serve to confirm the basic CDM paradigm while constraining the background cosmology parameters, the shape of the power-spectrum of primordial density fluctuations, the onset and duration of the reionization epoch, and the conditions which led to the first stars and quasars. We present results here for the currently-favored, flat ΛCDM model, for different tilts of the primordial power spectrum. These minihalos will also cause a “21-cm forest” of absorption lines, as well, in the spectrum of radio continuum sources at high redshift, if the latter came into existence before the end of reionization.

On the Detectability of the Cosmic Dark Ages: 21-cm Lines from Minihalos

Hugo Martel
Paul R. Shapiro
Ilian T. Iliev
Evan Scannapieco
Andrea Ferrara

INTRODUCTION

No direct observation of the universe during the period between the recombination epoch at redshift \( z \approx 10^3 \) and the reionization epoch at \( z \gtrsim 6 \) as yet been reported. While a number of suggestions for the future detection of the reionization epoch, itself, have been made, this period prior to the formation of the first stars and quasars – the cosmic “dark ages” – has been more elusive. Standard Big-Bang cosmology in the CDM model predicts that nonlinear baryonic structure first emerges during this period, with virialized halos of dark and baryonic matter which span a range of masses from less than \( 10^4 M_\odot \) to about \( 10^8 M_\odot \) which are filled with neutral hydrogen atoms. The atomic density \( n_H \) and kinetic temperature \( T_K \) of the gas are high enough